I. C. 6433 MARCH, 1931

DEPARTMENT OF COMMERCE

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AMALGAMATION PRACTICE AT PORCUPINE UNITED GOLD MINES, LTD., TIMMINS, ONT.[1]

By Ronald A. Vary[2]

INTRODUCTION

This paper is one of a series prepared by the United States Bureau of Mines dealing with milling methods and costs. In view of the current revival of interest in gold mining, information dealing with practices and costs in the development of gold properties is apropos. Milling practice at a small gold property in the prospect stage is described where, with a small outlay for plant and equipment, development has been carried on for about 20 months on the proceeds of the mill operation with little additional expenditure.

The paper shows about what may be expected as to costs at a small property operated under northern climatic conditions and with rigid economy throughout the plant.

GENERAL DESCRIPTION

The Porcupine United Gold Mines is a reorganization of a group of claims formerly owned by Canadel Gold, Ltd. A considerable body of ore was partly developed by the former company, but work was stopped for four years or more until the property was taken up by the present company. The main claims where development work is being carried on adjoin the property of the Hollinger Gold Mines and McIntyre Gold Mines on their north boundary.

The ore which occurs in narrow but high-grade lenses is mined by shrinkage stoping. It consists of quartz with fine stringers of mineralized basaltic schist, or of banded quartz schist, or of stringers of quartz in schist, accompanied by pyrite and often containing visible gold. The gangue rock is basaltic schist.

The mill is an amalgamation plant of 25 tons daily capacity, installed as a pilot mill to help defray costs of development and to treat high-grade ore, with a cyanide plant the final objective as soon as mining developments warrant one.

Water for the mill is obtained from the mine, the underground pumps discharging directly to the mill tank.

Power is furnished by the Northern Canada Power Co. which supplies all the mines of northern Ontario. The power is transmitted from hydroelectric plants at 11,000 volts and is stepped down at the property to a 550-volt, 3-phase, 25-cycle current which operates all mine motors.

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1 - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6433."

2 - One of the consulting engineers, U. S. Bureau of Mines, and mill foreman, Porcupine United Gold Mines, Ltd.

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About 75 per cent of the gold in the ore is free milling and is mostly fairly coarse.

The plant was put in operation on March 24, 1929, and has treated 20 to 30 tons of ore daily up to the present.

CRUSHING

Hoisting and crushing are done on day shift only. Large pieces of barren rock are sorted from the ore underground and disposed of as waste. The milling ore is trammed to the shaft and hoisted to the surface in cars of approximately 1-ton capacity. The crushing plant is located in the shaft house and the ore is dumped as hoisted on a grizzly of 40-pound rails spaced 5 inches apart, which covers the whole of the crusher ore bin. Large chunks are broken up and put through the grizzly by the shaft deck man. The capacity of the crusher bin is 15 tons. The crude ore is fed to a 7 by 10-foot Allis-Chalmers jaw crusher driven by a 15-hp. motor. The crusher breaks the ore to 1 by 1-1/2 inches and discharges it to a 12-inch conveyor belt, feeding a 10 by 18 inch Allis Chalmers rolls (see flow sheet, fig. 1). The product from the rolls, 75 per cent of which is less than 1/2-inch mesh, falls on a 12-inch conveyor belt, traveling 100 feet per minute, and is conveyed to the mill which is located 75 feet from the shaft house. A 10-hp. motor belted to a countershaft drives the rolls and the roll-feeder conveyor. Both rolls are operated at 90 r.p.m. Occasional burning off of high ridges on the shells is required to keep them in shape. The crusher plant is operated by one man who does the necessary repair work and helps in the mill when he is not tending the crusher. The 12-inch conveyor discharges into the boot of an elevator with 10-inch buckets spaced 18 inches apart, 33-foot centers, speed 250 feet per minute, which delivers the ore to the mill bin. This bin is 12 by 12 by 10 feet and is constructed of 3-inch planks. It has a capacity of about 50 tons.

GRINDING

Grinding is done in a 4-1/2-foot by 16-inch Hardinge mill, carrying a ball load of approximately 4,000 pounds. It is operated at 31 r.p.m. and grinds an average of 25 tons of ore per 24 hours to 65 per cent through 200 mesh. A circulating load of 125 per cent is maintained in the ball mill. The discharge from the ball mill contains 32 to 36 per cent solids. Four-inch forged-steel balls are used. Their wear is approximately 1-1/2 pounds per ton of ore ground. The standard, wedge-bar, manganese-steel liners in the mill last 12 to 15 months. The ball mill is in closed circuit with two amalgamation plates and a 4 by 15 foot Duplex Dorr classifier inclined 2 inches to 1 foot and making 26 strokes per minute. The classifier rake product is returned by gravity to the ball-mill feeder scoop where water is added for regulation of the moisture content of the ball-mill charge. The overflow of the classifier is sampled hourly by hand by taking dip samples from its overflow launder. The ball-mill is belt-driven from a line shaft which is belted to a 50-hp. motor. The line shaft and motor supply power for all mill machinery including the 12-inch conveyor belt from the crusher plant and the elevator. The Dorr classifier is driven by a 5-hp., 3-phase, 550-volt motor.

AMALGAMATION

The ball-mill discharge falls into a distributing box where water is added and the flow distributed to two 4 by 8 foot copper amalgamation plates 1/8-inch thick and with a slope of 1-5/8 inches to 1 foot. The distributing box traps considerable coarse gold. The

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box is cleaned out once a week and its contents are run through an amalgamation barrel. The table frames supporting the amalgamation plates are constructed of 2 by 4 inch lumber, with cross pieces placed on edge and spaced 6 inches apart. The table decks are made of 1-inch shiplap on which the copper plates are screwed. The slope of the deck can be changed to suit conditions by placing wedges between the deck and the table frame. The plates are not silvered and the copper has to be treated with a weak cyanide solution before the mercury will amalgamate with the copper. Little trouble has been experienced by copper showing on the plates.

Mercury is shaken on the top half of the plates and none is added elsewhere. The plates are ordinarily dressed every three hours, but oftener if the ore is rich, depending upon the judgment of the operator. The method employed in cleaning a plate is to by-pass all the feed to the other plate, clean off all ore particles, then brush the plate well with a stiff whisk broom, working any loose amalgam to the top of the plate. This loosened amalgam is removed and if this leaves the plate too dry, mercury is shaken on and rubbed in well. The plate is then brushed horizontally, working from the center to the sides and starting at the bottom and working to the top of the plate. Any amalgam or loose mercury adhering to sides of the plate is then brushed to the top or removed if the amount is appreciable.

On the morning shift the plates are given an extra brushing and mercury is added to loosen the amalgam. Then the amalgam is stripped off with a piece of rubber conveyor belting, stripping being done horizontally to the flow on the plate; the amalgam is lifted and the plates are redressed in the usual manner. Care is taken that the plates are not stripped too clean.

Very little crystallization of the copper takes place, and the plates are rubbed occasionally with a weak cyanide solution which removes any tarnish or stains. Sufficient water is used to maintain an even flow of pulp over the plates and when the ball-mill discharges too much coarse material, the feed is cut off for a short period. Forty per cent of the total gold recovery is made on the amalgamation plates.

BLANKET TREATMENT

On the lower end of each table below the amalgamation plate, a sheet of 1/8-inch iron plate, 42 by 48 inches, is fastened. A blanket of No. 6 silence cloth is laid on this plate and secured by a flat iron bar 1/8-inch thick and 2 inches wide laid on top of the blanket. The bar is held by notches cut in the table frame. The pulp from the amalgamation plates passes over the blankets and pyrite, fine gold, and mercury from the plates are caught on the blankets. The blankets are changed and washed in a tub after each dressing of the plates, the blanket concentrates being sent to the amalgamation barrel for treatment. The plate and blanket tailings drop to amalgam traps at the end of each table and are elevated therefrom by an 8-inch bucket elevator which returns them to the Dorr classifier. This elevator has a deep sump which is a good trap and which is cleaned out at regular intervals. Amalgamation takes place in the whole circuit. Elevator discharge launders, classifier and other launders, all collect rich sands and amalgam; these are cleaned out periodically and treated in the amalgamation barrel. Thirty-five per cent of the gold is recovered by barrel treatment.

CONCENTRATION

The rake product from the Dorr classifier is returned to the ball mill, and the

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overflow runs by gravity to a Gibson impact amalgamator, attached to a James sand concentrating table. The amalgamator catches float mercury and fine gold which has escaped the amalgamation plates, blankets, and traps. The amalgamator is opened, washed, and its plates are scraped once a week. The James table is operated at 250 r.p.m. with a 3/4-inch stroke. The table concentrates, averaging $40 per ton, are dewatered and sent for cyanide treatment to an affiliated company. The table tailings are elevated by an 8-inch bucket elevator to the tailings dump. The table concentrates and table tailings are both sampled hourly by hand by taking dip samples from their launders.

BARREL AMALGAMATION

The concentrates or sands from the blankets, traps, launders, etc., are ground for 10 hours in a cast-iron amalgamation barrel, 16 inches in diameter and 36 inches long, revolving at 22 r.p.m., using worn balls from the ball mill as grinding media. Then about 250 ounces of mercury and 3 pounds of slacked lime are added to the charge and it is again ground from 5 to 8 hours. The barrel is washed out into a box, the iron balls are carefully cleaned by hand, and the residue is run over a small amalgamation plate to the mill circuit. The mercury and amalgam are collected, washed, and cleaned with hot water and then squeezed by hand through fine sheeting to eliminate excess mercury, retaining the amalgam in the form of a ball.

The amalgam is retorted outside the mill over a wood fire at regular intervals, using a cast-iron retort which has a capacity of 1,000 ounces. The sponge gold recovery is 35 to 40 per cent of the weight of the amalgam retorted and the mercury loss is small. The sponge gold is melted in an oil-burning furnace at the affiliated company's refinery. Soda, borax, and manganese dioxide are used for flux, and the moulds are coated with lampblack. The bullion is sampled by drilling small holes in opposite ends of the bar at top and bottom. The average grade of bullion is: Gold, 770 fine; silver, 120 to 140 fine.

The crew for the mill consists of two amalgamators working eight hours each. On the day shift the mill is operated by a mill foreman who takes care of cleaning the amalgam, retorting, and melting.

On a per-ton basis, labor costs are as follows:

	Man-hours per ton
Crushing	0.32
Amalgamation	0.64
Plant foreman	0.32
Total labor	1.28

Table 1.--Assays

	Gold content per ton
Average heads to amalgamation plant	$11.00
Table heads (amalgamation, tailings)	2.80
Table tailings	1.80
Table concentrates	40.00

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Table 2.—Operation costs per ton of ore treated

	Labor	Power	Supplies	Total
Crushing	$.214	$.135	$.035	$.384
Grinding	.429	.180	.162	.771
Classifying, screening, conveying, and refining	.429	.090	.107	.626
Miscellaneous			.070	.070
Totals	$1.072	$.405	$.374	$1.851

Table 3.—Unit supply consumption

1. Steel and Iron	
Ball consumption, pounds per ton ore milled	1.50
Liner consumption, pounds per ton ore milled	.48
2. Mercury, ounces per ton ore milled	.05
3. Power, kw.h. per ton ore milled	40.00

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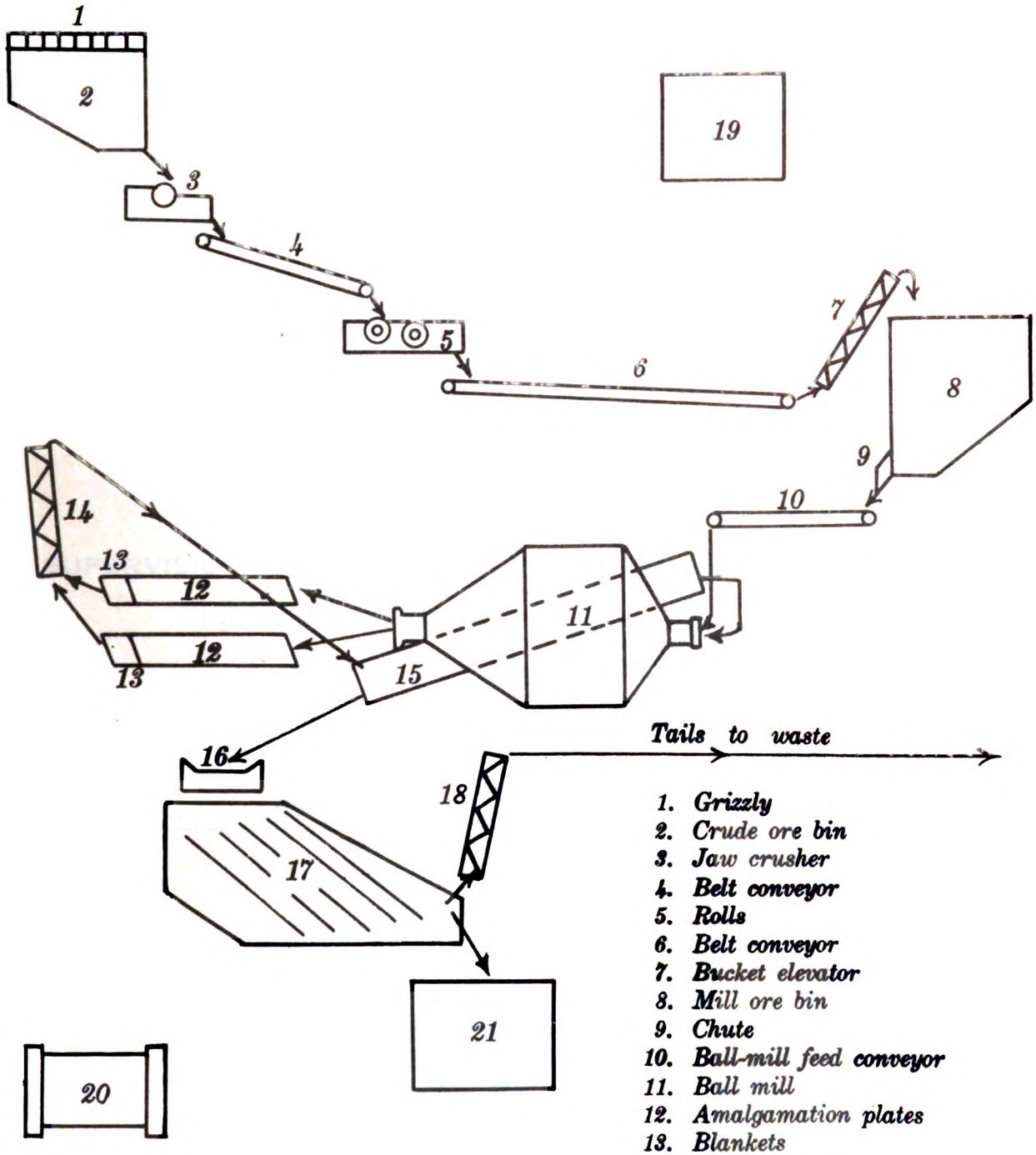

1. Grizzly
2. Crude ore bin
3. Jaw crusher
4. Belt conveyor
5. Rolls
6. Belt conveyor
7. Bucket elevator
8. Mill ore bin
9. Chute
10. Ball-mill feed conveyor
11. Ball mill
12. Amalgamation plates
13. Blankets
14. Bucket elevator
15. Dorr classifier
16. Gibson amalgamatior
17. James tables
18. Tailings elevator
19. Water tank
20. Amalgamation barrel
21. Concentrates bin

Figure 1. — Flow sheet

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